Implementing Accountability within a Multipollutant Air Quality Management Framework

by William Pennell, Richard Scheffe, Jeff Brook, Kenneth Demerjian, George Hidy, James Vickery, and Jeffery West

In 2004, the National Research Council (NRC) published a major assessment of air quality management practices, *Air Quality Management in the United States*.[1] Although the NRC report was aimed at the U.S. environmental management system, its recommendations—specifically, that the United States transition from a pollutant-by-pollutant approach to air quality management to a multipollutant, risk-based approach that emphasizes results over process—are also relevant to Canada and Mexico. For example, Canada is also assessing its approach to air quality management: namely, that a pollutant-by-pollutant approach may not always result in air quality management actions that are most efficient and effective in protecting human and ecosystem health. In Mexico, the situation is different. Mexico is focusing its attention on the potential benefits of managing greenhouse gas emissions in concert with traditional air quality-related emissions. However, Mexico closely tracks air quality management developments elsewhere. If a multipollutant approach were shown to have clear advantages, it could influence Mexico's approach to air quality management as well.

The argument for transitioning from current air quality management practices to a multipollutant, results-oriented approach is based on both administrative and technical considerations. Emission sources are linked via atmospheric chemistry, transport, and deposition. Thus, susceptible individuals and ecosystems are exposed simultaneously to multiple pollutants from a variety of sources. These linkages also contribute to multiple pollutant interactions that can confound source receptor relationships and lead, possibly, to synergistic effects on human and ecosystem health. Further discussion of the rationale for adopting a multipollutant approach to air quality management, and some initial thoughts on how this approach might be implemented, are provided in companion articles in this issue. This article will focus on the results-oriented or "accountability" aspects of these emerging air quality management frameworks.

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ACCOUNTABILITY IN AIR QUALITY MANAGEMENT

One of the principal recommendations of the 2004 NRC report was that progress in air quality management should be measured in terms of performance outcomes—in other words, in terms of how effective air quality management actions have been in improving human and ecosystem health. Such a focus is clearly in concert with the intent of the Clean Air Act: The justification for taking actions to reduce exposure to air pollution is to reduce its adverse effects. But measuring the success of air quality management actions in terms of their direct benefits to human and ecosystem health has not been the traditional approach. Traditionally, the success of air quality management actions has been judged according to whether or not they have been successful in reducing emissions or achieving attainment of the National Ambient Air Quality Standards (NAAQS).[2] There are good reasons for this. One is that standards are set on the basis of scientific information that indicates that if the NAAQS are achieved, the health of exposed populations will be protected with an adequate margin of safety. Another is that demonstrating that a given management action has resulted in a measurable reduction in adverse health or ecosystem effects is not easy to do.

The process of evaluating the effectiveness of air quality management actions in terms of their success in achieving air quality management goals is frequently called "accountability." It is implemented through a series of steps that form the accountability chain. These steps determine whether or not (1) the expected emission reductions have taken place, (2) the actual or estimated emission changes resulted in

ambient concentrations or deposition changes, (3) the changes in ambient concentrations or deposition have resulted in reductions in the exposure of humans or ecosystems to the pollutants in question, and (4) these reductions have led to improved public health and reduced stress to sensitive ecosystems.

In addition to measuring the effectiveness of air quality management actions, accountability can also be part of a process of "continuous improvement." Each step down the accountability chain provides information that can be used to improve effectiveness or lower the cost of the original air quality management action. These attributes of accountability are shown in Figure 1. The figure also illustrates the principal challenge of implementing accountability. For each step down the accountability chain—from emission reductions to health or ecosystem effects—it becomes increasingly difficult to establish a clear cause-and-effect relationship. Emission changes, for example, may occur due to changes in economic conditions or from the adoption of new technology for reasons unrelated to air quality management. Likewise, the principal health effects attributed to air pollution (i.e., respiratory stress and heart disease) are also driven by other confounding factors, some of which have much greater impact on one's susceptibility to developing these diseases (e.g., smoking or changes in health care practices) than ambient air pollution. The problem of establishing cause and effect becomes particularly difficult for air quality management actions that are implemented over a number of years. The longer it takes to implement the air quality management action, the greater the possibility that any observed health outcomes will be affected by confounding factors or that additional actions will have taken place, during the same timeframe, that complicate the ability to attribute cause and effect.[3]

The most successful demonstration of accountability to date has been the reduction of lead concentrations in the air due to the phasing out of lead-containing additives in gasoline fuel. In this case, the air quality action targeted mainly a single source, and there was an easy-to-measure biomarker (i.e., lead levels in the blood of the U.S. population) directly related to the adverse health effect in question that could be used to measure the action's effectiveness. This success is to be contrasted with actions beginning in the late 1970s to address the ozone (O_3) problem using a volatile organic compound (VOC)-only reduction strategy. Although these actions were based on the best available science at the time, they were undertaken without adequate success measures (e.g., measurements to assure that the expected O_3 reductions were occurring) or management strategy to allow rapid adjustments to these actions if they proved to be ineffective. It was partially this experience, combined with the later adoption of a nitrogen oxides (NO_x) control alternative, that motivated the initial calls to make accountability part of the air quality management process.[4-6]

More recent calls for the inclusion of accountability as part of any quality management plan result from the increasing complexity of the air quality management problem. As previously noted, pollutants such as O_3, particulate matter (PM), and certain hazardous air pollutants (HAPs) are linked via sources and atmospheric chemistry. Most of the obvious actions for reducing atmospheric concentrations of O_3 and PM have been taken. Further reductions in ambient concentrations and exposure will undoubtedly call for strategies that target specific sources and exposure "hot spots" (i.e., localized areas where exposure to one or more pollutants is significantly higher than surrounding locations), account for the secondary sources via atmospheric chemistry, and consider the implications of international and hemispheric transport.

This process is beginning now. Over the next decade, decision-makers in Canada and the United States are expected to conduct key assessments of the effectiveness of past air quality management practices. By 2010, major air pollution reduction programs at the federal, state, and provincial levels will be in place under recently adopted rules. Although full implementation of their provisions may be incomplete, major reductions in emissions are expected by then. As these programs take effect, air quality managers will be placing greater emphasis on tracking compliance and progress toward meeting health and environmental goals. They will also be considering the need to take additional actions to meet these goals if compliance or progress is not sufficient. As they track progress, air quality managers will need to demonstrate whether or not recent emission reduction programs have been effective in reaching air quality targets for protecting human health and sensitive ecosystems. It will not be sufficient to show that ambient concentrations of individual pollutants have decreased with emission reductions. It will also be necessary to show that they have decreased as expected; and if they have not, or if expected improvements in human and ecosystem health have not occurred, air quality managers will need to determine why.

If these air quality management assessments show that past measures have been ineffective in achieving established goals, if health and environmental goals are modified, or if emerging science indicates the need for revised approaches, adjustments to existing air pollution control measures must

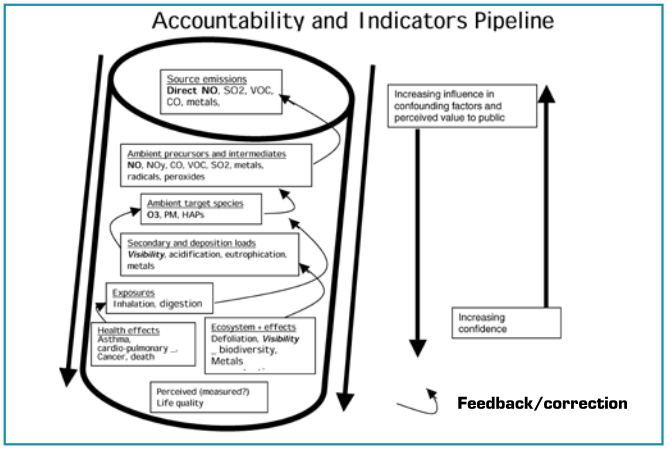

Figure 1. Indicators pipeline extending from source emissions through human and ecosystem health effects.

Notes: Bold downward arrows on either side of the pipeline indicate the direction an accountability process is implemented. As one moves down the accountability pipeline the probative value of the information increases, but confidence in drawing cause-and-effect conclusions decreases.

be made. Since these adjustments may need to incorporate a multipollutant strategy, multipollutant tools and information will be required to complete the accountability process by (1) establishing and confirming progress toward air quality, public health, and environmental goals (e.g., as set by dose–response targets); (2) determining the adjustments to existing emissions controls that might be needed if progress is not sufficient; and (3) providing information that will assist decision-makers in making hard choices among air quality goals and/or emission reductions, especially when the resources for achieving these goals or reductions are constrained.

THE NARSTO ASSESSMENT

To determine the tools and information that would be needed to support the design and implementation of a multipollutant, results-oriented management approach, NARSTO is undertaking an assessment of the technical challenges of implementing accountability within a multipollutant air quality management framework. The intention is to complete the assessment by the end of 2008 so that decision-makers will have information they may need to perform periodic accountability studies that address air quality management performance targets. In the United States, these studies are expected to begin in 2010 and to be repeated on a 5- to 8-year cycle.

In principle, the NARSTO assessment will follow a risk assessment approach. It will start with specification of the health and environmental goals of the air quality management plan and work backward to identify the information that is needed to determine whether or not these goals are being achieved. Each step of the accountability process—verifying emission reductions, measuring pollutant concentrations, evaluating exposure, and assessing the effects on human and ecosystem health—requires different information and each represents a greater technical challenge. The principal objective of the assessment will be to evaluate the feasibility of completing each step and to identify what additional research or information requirements will be needed to meet the goal of evaluating air quality management actions in terms of their desired effects. The assessment process is depicted schematically in Figure 2.

Establishing a Conceptual Framework

The first task is to establish a conceptual framework for implementing a multipollutant, results-oriented air quality management process that includes a means for measuring progress in meeting air quality management goals. Such work is already underway at the U.S. Environmental Protection Agency, and this work will help form the NARSTO conceptual model. The framework will include identifying priority-setting methods that could be adopted as supplements to current national practices.

Identifying Data Requirements

The next two tasks are to identify the data needs for evaluating the effects of air pollution on human and ecosystem health. These needs will be established through a series of similar workshops. To determine the data needs for evaluating the effects on human health, for example,

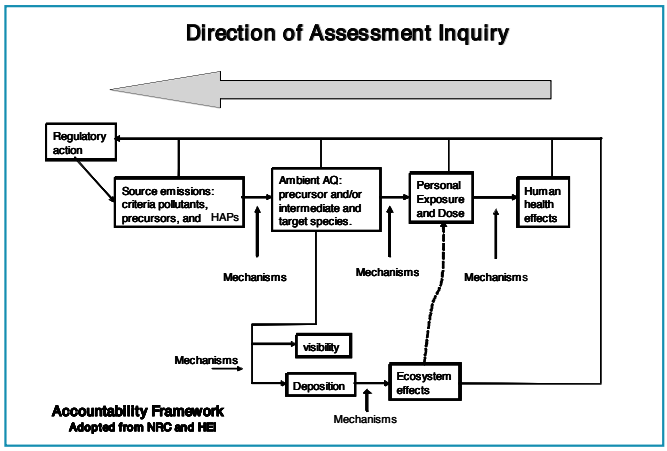

Figure 2. Conceptual approach for conducting the NARSTO multipollutant assessment.

health, human exposure, and air quality scientists will meet in a special workshop. The workshop will identify the air quality measurements, source characterization, and interpretive information needed by human exposure and health scientists to

- establish a baseline from which to measure apparent change and to separate out cause and effect (assuming that effects can be differentiated by disease class or some other means);
- associate health and exposure changes under current standards with air quality and source emission changes; and
- investigate the implications of possible health-effect synergisms that may be associated with exposure to multipollutant mixtures, including designated criteria pollutants and HAPs.

A similar process will be followed to determine the data needs and technical challenges of assessing the effects of air pollution on aquatic and terrestrial ecosystems.

In parallel with these fact-finding tasks, an assessment team will evaluate the technical challenges of implementing risk-based, multipollutant air quality management planning for the three countries of North America (Canada, the United States, and Mexico). The principal challenges currently identified are separating the effects of meteorological variations from the air quality record, accounting for the relationships between air quality and climate change, determining the contributing source emission changes responsible for observed air quality changes, determining how these air quality changes affect exposure, and assessing the consequences to human and ecosystem health.

Achieving this list of goals includes differentiating between the effects of emission reductions due to specific air quality management actions and the contributions of long-range transport to local air quality. The plans of this part of the NARSTO assessment include an identified set of measurements, source characterizations, and an assessment protocols to track progress in meeting air quality goals and to relate this progress to specific source emission changes; an atmospheric sciences assessment of the capabilities for

meeting these needs; and an identified course of action to fill the gaps. These plans include specific recommendations on how the atmospheric science, health, and ecosystem-effects communities can coordinate efforts to complete the accountability chain from air quality management actions to responses, or lack thereof, at the intended health or ecosystem endpoints.

Documenting Results

The final task will be to document the results of the assessment. Documentation is planned through a series of informal topical reports, one for each of the review areas (human and ecosystem health), and a stand-alone synthesis report on the technical challenges and the implications of a multipollutant approach to managing air quality through periodic accountability assessments. This synthesis will include a combined set of accountability needs, an assessment of existing and projected capabilities for meeting these needs, recommendations for strengthening these capabilities, and a description of the activities required to perform multi-pollutant assessments of progress in meeting air quality, public health, and environmental goals.

SUMMARY

Air quality managers in North America are faced with the challenge of continuously improving the effectiveness of air quality management actions and of evaluating the success of past measures. In the United States, consideration is being given to shifting from a pollutant-by-pollutant approach to a multipollutant air quality management plan that uses accountability both as a means for evaluating the effectiveness of past air quality actions and for providing the information needed to revise past actions if this proves necessary. It remains an open question as to whether or not we have the technical capability and monitoring data that would be needed to fully implement a multipollutant air quality management approach as envisioned by the NRC. The recently implemented NARSTO assessment is intended to address this question. **em**

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